(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 March 2005 (24.03.2005)

PCT

(10) International Publication Number
WO 2005/025844 A1

(51) International Patent Classification[7]: B29D 11/00, G11B 7/24, 7/26, 3/70, 5/84

(21) International Application Number:
PCT/US2003/041715

(22) International Filing Date:
24 December 2003 (24.12.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/499,002 2 September 2003 (02.09.2003) US

(71) Applicants *(for all designated States except US)*: NEW MEDIUM ENTERPRISES, INC [US/US]; 1510 51 Street, Brooklyn, NY 11219 (US). MAGNITSKII, Sergei [RU/RU]; 9/76 Garibaldi Street, 117313 Moscow (RU).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: LIBIN, Alexander [IL/IL]; 7, York Steiner Street, 69860 Tel-Aviv (IL). MALAKHOV, Dmitrii [RU/RU]; 339/51/2 Kashirskoye Shosse, 115211 Moscow (RU).

(74) Common Representative: NEW MEDIUM ENTERPRISES, INC; 1510 51 Street, Brooklyn, NY 11219 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2005/025844 A1

(54) Title: MULTILAYER REFLECTIVE INFORMATION CARRIER AND METHOD FOR MANUFACTURING THEREOF

(57) Abstract: A method for manufacturing of a multi-layer optical carrier comprising forming a plurality of optically transparent layers having a surface relief in a form of information pits and spaces therebetween, coating the surface of each of plurality of optically transparent layers with at least partially reflective layer, further coating at least partially reflective layer with a planarizing layer with removing planarizing layer from spaces and partly from the pits and further removing reflective layer from spaces and from top portions of the pits.

MULTILAYER REFLECTIVE INFORMATION CARRIER AND METHOD FOR MANUFACTURING THEREOF

FIELD OF THE INVENTION

The present invention relates to Multilayer Optical Information Carriers (MOIC) as well as to the methods used in their production.

BACKGROUND OF THE INVENTION

Already more than five years, the worldwide TV and cinema movies market is ready to introduce the high-definition TV (HDTV). However, the present CD/DVD industry cannot produce an optical disc that complies with the HDTV technical requirements. The main problem is insufficient memory capacity of such carriers. During the last years, attempts were made in the field of the CD/DVD technology to solve this problem by increasing both a recording density in a layer and the number of layers. However, as is known in the art, the developed CD/DVD technologies [Bouwhuis G et al, "Principles of Optical Disc Systems", Philips Research Lab., Eindhoven, Adam Hilger Ltd] do not allow creating carriers with the number of layers more than two.

Increasing recording density on a layer in a direct way presents serious technological problems (a necessity to use expensive blue lasers and technologies that are on the edge of the present mass-production capabilities).

One of the methods used to increase the number of information layers consists in using fluorescent compositions in production of information carriers, as was proposed, for example, in US Patents No 6,009,065 and No 6,071,671. However, when developing information-carrier fluorescent systems similar to CD- or DVD-systems, a serious problem arises – a small value of information signal. Besides, because of organic dyes that are used in the fluorescent discs technology, the number of reading cycles and the life period of fluorescent discs are limited.

An alternative method that allows implementing multiplayer optical memory is the method based on island-like, partially reflective information-carrier elements. The substantial advantage of this approach is a significant increase in information signal intensity during the reading cycle when this value is compared with that of the system of fluorescent multiplayer optical memory. At the same time, due to the fact that the total surface occupied by the information pits in the CD-standard amounts approximately to 1/8-th of the total surface of the information field, and in the DVD-standard - approximately to ¼-th, when pits are filled partially by, for example, the half-reflective coating, the information layer as a whole can

reflect no more than 5-10% of the incident radiation, that allows to implement from 5 to 10-layer information carrier system. This is the main difference between the proposed information carriers and the traditional systems of ROM-type in which information layers are covered in full by a partially reflective coating, for example, by metal coating, and the recorded information is read by the interference method. This last fact limits substantially a possibility of their application in the multi-layer information structures. In US Pat No 4,090,031, a structure of multi-layer reflective disc is disclosed; in this disc, the information carrier elements are produced, in particular, from the reflective material, and at the same time, the main part of the layer is made of a transparent material. To produce information carrier layer, it is suggested to use the photolithographic methods, in particular, to implement the photo-resist technology with exposition, development, and hardening of the photosensitive layer, with the subsequent etching of a metal through a photo resist mask. Such approaches are distinctly developed, however the price of the products produced by such method increases substantially when decreasing dimensions of its elements and increasing the surface of the product itself. By this reason, for a ROM-type optical memory system produced in compliance with CD/DVD-standards, application of such photolithographic technology appears to be inefficient.

In US Pat No 6,309,729, the method of production of fluorescent multi-layer information carrier is disclosed; the information-carrier elements thereof are produced from a fluorescent material surrounded by a reflective material. The method of "metallization" of such disc is disclosed; it is similar to the method proposed in US Pat No 4,090,031 and mentioned above. The disclosed method is characterized by a lower cost but has an important disadvantage because the production of metal structures of sub micron dimensions through one-stage etching is possible only by dry etching when expensive and ecologically dangerous reagents are used.

SUMMARY OF THE INVENTION

There is accordingly a need in the art to provide a novel method for manufacturing of a Multilayer Optical Information Carriers, particularly such a method which is suitable for mass production of the multi-layered optical memory devices.

Thus, according to one aspect of the present invention, there is provided a method for producing a multi-layer optical carrier comprising forming a plurality of optically transparent

layers having a surface relief in a form of information pits and spaces therebetween, coating the surface of each of plurality of optically transparent layers with at least partially reflective layer, further coating at least partially reflective layer with a planarizing layer with removing planarizing layer from spaces and partly from the pits and further removing reflective layer from spaces and from top portions of the pits.

Two-stage etching may be applied to form sub micron information-carrier elements. Application of the modified master production method may be applied for manufacturing information layers of ROM-type with the information pits formed as partially reflective micro areas on a transparent background.

In accordance with one aspect of the present invention, to produce Multi-layer Optical Information Carriers (MOIC), it is suggested to apply modified technology used in production of traditional CD/DVD-discs and the partially modified photolithographic technology used in the master production. Initially, by using the traditional methods of injection molding or photo polymeric replication, a pattern-carrying polymeric master with information pits in a form of micro cavities may be manufactured; after this, on its surface, a partially reflective layer, for example, a metal layer may be applied. The metal is deposited both inside information pits and in the spaces in between. Then, a planarizing coating is applied and thereafter etched, preferably, through plasma-chemical methods. Preferably, etching continues until a mask of planarizing coating is left inside pits only. More specifically, planarizing coating may be partly removed from the top portion of the pits. After this, preferably, liquid etching of the bare metal surface is applied removing metal reflective layer from said spaces and preferably, from top portions of the pits. Thus, micro areas of the planarizing coating left at the bottom of the information pits after the initial etching, play a role of the protective mask preventing the metal within these areas from being etched out. In addition, in distinction from the method proposed in US Pat No 6,309,729, a layer of reflective metal occupies only the lower part of the information pit, that gives a substantial increase in accuracy the reflective elements can give. Besides, carrying the etching process in two stages is preferable. The problem is that when using the liquid reagents (etching agents) under the condition that both the mask material and the metal are exposed to etching, it is practically impossible to obtain the sub micron metal structures. In this case, due to wettability, etching will take place preferably along the metal surface. In the case of dry (plasma chemical) etching, it is quite difficult to select a mask material having the etching speed lower than the speed the metal is etched with. In addition, to etch metals under conditions of the plasma chemical process, expensive and poisonous materials are used, for example, boron tri-chloride and so on. By carrying out the

etching in two stages, the first stage can be done in air plasma, and the second stage - in liquid etching agents having a high selectivity.

More specifically the present invention is used for manufacturing multi-layered compact discs and is, therefore, described below with respect to this application.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 illustrates the one-stage etching procedure of MOIC production (a prior art method).

Fig. 2 illustrates step forming one of plurality of optically transparent layers having a surface relief in a form of information pits and spaces therebetween (production of information-and-carrier replica);

Fig. 3 illustrates step of coating the surface with at least partially reflective layer;

Fig. 4 illustrates step of coating reflective layer with a planarizing layer;

Fig. 5 illustrates step of removing planarizing layer from spaces and partly from the pits;

Fig. 6 illustrates step of removing reflective layer from spaces and from top portions of the information pits;

Fig. 7 illustrates step of application of adhesion layer; and

Fig 8 illustrates step of forming the next information-and-carrier replica and for production further information layer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The disclosed Multilayer Optical Information Carrier (MOIC) consists of a few information layers deposited on a base layer - substrate. In each of these layers, the information is recorded in a form of islands made of partially reflective material (for example, metal) that are located inside a transparent polymeric material. A separating layer separates the neighboring information layers from each other. All the information and separating layers have the same or nearly the same refractive index at the wavelength of the reading radiation with the purpose to remove parasitic reflection that may occur at the interlayer borders.

Information layers represent a planarizing structure similar to the master structure that was received by the method of liquid etching of the continuum, partially reflective layer

through the protective mask that was formed, in its turn, by means of plasma chemical partial etching of the continuum planarizing layer applied on the partially reflective layer. The minimal size of the information area (pit) is determined by the resolution of the reading device and can reach, for example, 0.4 μ. The separating layers are necessary to maintain a given distance between the information layers to ensure small interlayer errors. Typical values of distances between information layers are in the range from 10 to 100 μ.

The MOIC multiplayer structure is located on the substrate manufactured from the material of an optical quality that is capable to add necessary mechanical properties to the product as well. As the substrate layer material, such materials as, for example, glass, quartz, transparent polymers, such as polycarbonate, polyarylate, polyalkylakrylate, polyalkylmetakrylate, polycycloolephin and so on can be used.

Each MOIC layer is manufactured separately. To produce a layer, it is necessary to have an information-carrying master (for example, made of nickel) with the aspect ratio ranging from 0.3 to 0.5 (the standard value is 0.15 for CD and 0.3 for DVD).

The technological procedure used to produce MOIC can include the following operational sequence:

1.The production of polymeric replica (copy) with pits in a form of micro cavities by the methods known in the art, for example, in the technology of CD-DVD optical discs production (injection molding or photo polymeric replication) with the information-carrier, for example, the nickel master with information-carrier;

2.Then these replicas are covered, by example, by a continuum thin partially reflective layer of a metal or dielectric material by the method of thermal spraying in vacuum;

3.After that, the intermediate products received as a result of the above procedures are coated by a thin planarizing polymeric layer by the method of dipping or centrifuging with a subsequent drying;

4.Following planarizing-layer forming and drying, plasma chemical etching processes these intermediate products. In this process, the planarizing coating is etched out completely from the vertical surface and partially (approximately, by half) is etched from pits. Therefore, in these pits (micro cavities), after the initial plasma chemical etching, a layer of polymer is left that will further on play a role of protective mask during the subsequent etching of the partially reflective layer, for example, a metal layer;

5.Next, the intermediate products undergo an additional stage of liquid etching; during this stage the reflective layer (for example, a metal layer) is etched away from the areas

around information pits. At the same time, in the areas inside the pits, metallization remains intact due to a polymeric protective mask.

6.The obtained structure is covered afterwards by a thin adhesion layer a few microns thick. Due to this, the interlayer distance of 10-100 μ will be created mainly by an intermediate layer. In the other option, the adhesion layer is 10-100 μ thick and defines, mainly, the distance between the information layers.

And finally, the adhesion layer is applied thus completing the formation of one information-carrier layer, and the obtained structure is used then as a substrate to apply the next information layer according to steps 1-5. This sequence of operations can be repeated till the required number of layers is applied.

Additionally, it is possible to apply additional steps or combination thereof in order to improve quality of MOIC, e.g. plasma-chemical treatment of replica and/or at least some of the coatings (layers), deposition of antidiffusion diamond-like carbon (DLC) layer thereon, baking of planarizing layer, etc.

Referring to Fig. 1, there is illustrated the sequence of MOIC 100 production (prior art). The master 101 is used to obtain the replica 102, which is coated by a metal layer 103. The obtained metal-coated replica is coated then by the fluorescent composition 104, after that the structure is etched to a surface level; as a result, the fluorescent composition remains only inside pits thus preventing a metal inside pits from etching.

The sequence of technological operations used in MOIC production is given on Figs. 2-8. Fig. 2 shows schematically the process 200 of production of the polymeric replicas 201 on a transparent substrate 202 with the information-carrier master 203 by the method of UV hardening of the photo polymeric compositions 204 (or injection molding), that are used traditionally in production of CD-DVD optical discs. The difference between the proposed method and the traditional one lies in a higher value of the aspect ratio of the information pits 205 in the proposed method.

Fig. 3 shows schematically the process of application of the reflective coating on the polymeric replicas 201 that were obtained in the previous stage. The replicas 201, both in the deepen locations of information pits 301 and in the locations in between 302, can be coated by a thin partially transparent layer of metal and (or) dielectric material 303 with the help of the magnetron, plasma or electronically simulated thermal or any other deposition method. The thickness of the layer 303 is controlled and selected depending on the depth (the sequential number) of the layer in the multi-layer system. The deeper the layer is located in the multi-

layer system, the more is the refractive index and, correspondingly, the thicker metal layer must be formed on it. As a metal 303 used for deposition, it is possible to use, for example, aluminum, chromium, and vanadium to increase adhesion, silver, gold and so on. As a reflective dielectric coating 303, it is possible to use, for example, titanium dioxide, diamond-like film and other coatings having the refractive index different from the refractive index of the intermediate layers. It is important to provide a capability to etch a metal and (or) reflective dielectric layer in an easy and selective way, not damaging the mask material (see below).

Fig. 4 shows schematically the process of applying the planarizing coating 401 for leveling the surface 402 both above the locations of information pits 403 and between them 404. The planarizing coating 401 is applied by the centrifuging method or by sprinkling a polymeric solution. To remove completely solvent residues and eliminate a possibility of internal stresses in a layer during its formation, drying is carried out under a higher temperature and (or) in vacuum. As a polymeric base for a planarizing coating, it is necessary to use a polymer resistant to a further liquid etching of a metal layer or a mixture of polymers, such as: polyalkyl methatrylate, polyaryl methakrylate, polyalkyl akrylate, polyaryl akrylate, polyakryl nitrile, polybutadien, polyisoprene, polyethylene terephthalate, polychloroprene, polyethylene adipate, polyamide, polyvinyl chloride, polyvinyl fluoride, polyvinyl alcohol, polyvinyl chloride, polyvinyl butirale, polystyrene, polyalkyl styrene, polyhalogene styrene, polyoxymethylene, polyethylene oxide, polypropylene oxide, polytetramethylene oxide, olytetra methylene adipate, polyvinyl naphthalane, polyarylate, polytetra fluorine ethylene, polycarbonate, polyurethane, polymethyl siloxen, polyvinylalkyl ester, polyvinyl acetate, polyisobutylene, polyvinyl cinnamite, polyvinylphenole, and their alkyl- and aryl ether, polyether, polyvinyl pirrolidone and (or) their co-polymers. As solvents for polymers, it is necessary to use the thermo-dynamically "good" solvents with a low factor of surface tension. In the mixture of solvents used to apply a planarizing coating, it is necessary to have a high-boiling solvent component to improve the film-forming property and to decrease the defectiveness of a coating. To improve the planarizing capability, it is important to have a low value (< 10000 cP) of viscosity of the concentrated polymeric solution (>50 % mass). In general, it is required to use the polymers with as less molecular mass as possible.

Fig. 5 shows schematically the process of the plasma chemical etching of the planarizing coating 500. In this process, the planarizing coating 401 is etched deeply into pits thus uncovering the layer of the reflective coating 501 in the areas between information pits and in the upper part of pits. In pits (cavities), after etching, the polymeric layer 502 is left; this layer

will further play a role of a protective mask when the reflective coating will be etched the next time. Such methodology allows improving a reproducibility of the borders of the reflective element. Plasma for etching can be formed by means of low-or high-frequency discharge. Plasmatron can be implemented both with condenser power supply and induction supply. To allow a required uniformity in the process of etching, a rotation of samples must be provided. As etching reagents, such materials as air, oxygen, fluorine-containing etching agents, argon and other reagents can be used. The range of 1-100 Pa is preferable. A completion of the etching process can be controlled by means of emission spectroscopy of plasma discharge. For this, it is necessary to use a piece of optical wave-guide (multimode is preferred), one end of each is fixed in the vicinity of the plasma gun's inspection hole, and the other is fixed in the cuvette chamber of a spectrofluoscope. It is important to provide the maximum charge of the chamber, i.e. the total area of the processed samples must be comparable with the total area of the chamber walls. This condition is required to ensure a higher level of the response signal when etching is completed. Then a spectrum of plasma emitted in the process of samples etching is recorded. After taking a few measurements, a wave length is determined at which the point of etching completion can be seen the best; then this is exactly the wavelength used to measure a moment when etching is completed.

Fig. 6 shows the process 600 of etching the reflective coating. To etch the metal coatings, liquid reagents can be used (for example, solutions of organic and (or) inorganic acids, alkali and so on); to etch the reflective dielectric coatings, it is possible to use both liquid reagents and the plasma chemical etching methods. As examples of liquid-phase metal etching reagents, it is possible to use water, non-water and mixed solutions of inorganic acids, such as nitric, sulfuric, selenic, hydrochloric, hydrobromic, iodous and so on, either separately or mixed with organic acids, for example, alkylcarbonate, arylcarbonate, aliphatic, and aromatic sulpho acids, as well as additives improving etching selectivity, for example, metal salts and surface-and-active materials (surfactants), for example, salts of sulpho or carboxylic acids. Metal etching is carried out till the metal is totally removed (clarified) from the inter-pit space 601. The moment when etching is completed must be controlled based on transparency of a sample. At the moment when passing through reveals no substantial increase, the etching process must be stopped. As liquid etching reagents, it is possible to use, for example, the compositions based on hydrofluoric acid to etch the dielectric coatings of the titanium dioxide type. To etch the diamond-like reflective coatings, it is possible to use, for example, the plasma chemical etching in the oxygen-containing plasma.

Fig. 7 shows schematically how the adhesion layer 701 is applied. The adhesion layer 702 is required to improve strength properties when gluing the information-carrier layer 201 of MOIC to the subsequent intermediate pattern-carrying information layers. In addition, this layer 702 implements the protective functions through sealing the information-carrier structure 701. As an adhesive, it is possible to use such varnish as epoxy resin, urethane, akrylate, alkylakrylate, photo polymeric or thermo-consolidating varnish, including multi-component varnishes both those based on solvents and without them.

Fig. 8 shows schematically the process 800 of production of the next layer. It is shown that the information-carrier structure 701 formed on the previous stage of Fig. 7 plays a role of a substrate when the next layer 801 is produced.

In the following the present invention will further clarified by examples and reference non-limiting examples.

Example 1.

The aluminum metal is applied on the polycarbonate substrate manufactured on the standard DVD-discs production line by the method of injection molding through magnetron spraying; it is observed that the passing through at the reading-radiation wavelength amounts approximately to 50%. Then, in the centrifuge of the type used in CD-R discs production, the solution of polymethyl methacrylate (PMMC) (MV 15000) in ethyl cellosolve (7% by weight approximately) is applied. The application process is carried out with the speed of 3,000 revolutions per minute. Afterward, the obtained sample undergoes drying during 5 minutes at the temperature 60 ^{0}C; after that the sample goes through plasma chemical etching in the plasma gun PKhT 006 M of the condenser type during 5 minutes. The etching conditions are as follows: pressure - 20 Pa, airflow rate - 1.8 liter per hour, capacity - 250 W. Then, the sample is placed for 45 seconds in 4% aqueous solution of hydrochloric acid, rinsed in distilled water and dried by compressed air. After that, in the centrifuge, the adhesion layer consisting of 15% (by weight) of the solution of polyvinylbutyral in the mixture of isobutanole and hexafluoroisopropanole taken in the ratio 1:1 is applied. The adhesion layer goes through drying during 5 minutes at 60 ^{0}C. By such method, the single-layer sample is produced.

Example 2.

The diamond-like film having 100 nanometers in thickness is applied on the polycarbonate substrate manufactured on the standard DVD-discs production line by the method of injection molding through plasma stimulated spraying. After that, through the magnetron spraying method, the aluminum metal is applied by observing that the passing

through on the reading-radiation wavelength amounts approximately to 50%. Then, the diamond-like film having 100 nanometers in thickness is applied on the metal through the plasma stimulated spraying method. After that, on the centrifuge of the type used in CD-R discs production, the solution of polymethyl methacrylate (PMMC) (MV 15000) in ethyl cellosolve (7% by weight approximately) is applied. The application process is carried out with the speed of 3,000 revolutions per minute. Afterward, the obtained sample undergoes drying during 5 minutes at the temperature 60 ^{0}C, after that the sample goes through plasma chemical etching in the plasma gun PKhT 006 (ПХТ 006) M of the condenser type during 5 minutes. The etching conditions are as follows: pressure - 20 Pa, airflow rate - 1.8 liter per hour, capacity - 250 W. Then, the sample is placed for 45 seconds in 4% aqueous solution of hydrochloric acid, rinsed in distilled water and dried by compressed air. After that, on the centrifuge, the adhesion layer consisting of 15% (by weight) of the solution of polyvinylbutyral in the mixture of isobutanole and hexafluoroisopropanole taken in the ratio 1:1 is applied. The adhesion layer goes through drying during 5 minutes at 60 ^{0}C. By such method, the single-layer sample is produced.

Example 3.

An information pattern is moved from a nickel stumper onto a flat polycarbonate substrate in the process carried out on the standard DVD-discs production line by the method of photopolymerizing from the diacryl ether 1,6-hexanediolacrylate solutions. The obtained replica is washed by isopropyl alcohol in the centrifuge used in production of CD-R discs. To improve adhesion, the replica is processed in the plasma gun PKhT 006 (ПХТ 006) M of the condenser type during 30 seconds. The etching conditions are as follows: pressure - 20 Pa, airflow rate – 3.1 liter per hour, capacity - 200 W. Afterward, the chromium metal is applied in the magnetron spraying device in such a way that the passing through on the reading-radiation wavelength (650 nanometers) amounts approximately to 30%. Then, on the centrifuge used in production of CD-R discs, the solution of polystyrene (PMMA) (MV 8000) in the mixture of toluene with isobutyl acetate (8% by weight approximately) is applied. The application speed is 2,500 revolutions per minute. Then the obtained sample goes through drying during 20 seconds at 60 ^{0}C, afterward the sample undergoes plasma chemical etching in the plasma gun PKhT 006 (ПХТ 006) M of the condenser type during 50 seconds. The etching conditions are as follows: pressure - 20 Pa, airflow rate – 1.5 liter per hour, capacity - 500 W. Then, the sample is placed for 3 minutes in the aqueous solution containing 12.5% NaOH and 22.5% K3Fe(CN)6, rinsed in distilled water and dried by compressed air. After that, on the centrifuge, the adhesion layer consisting of 15% (by weight) of the solution of

polyvinyl acetate in the mixture of isopropanole and acetonitryle taken in the ratio 2:1 is applied. The adhesion layer goes through drying during 3 minutes at 60 ^{0}C. By such method, the single-layer sample is produced.

Example 4.

An information pattern is moved from a nickel stumper onto a flat polycarbonate substrate in the process carried out on the standard DVD-discs production line by the method of photopolymerizing from the Epoxy Novolac Acrylate CN112B70 (Sartomer). Then, the obtained replica is rinsed in the mixture of isopropylene and ethyl alcohol (1:1) on the centrifuge used in the CD-R disks production. After that, to improve diffusibility, the replica is coated by a film of silicon dioxide (50 nanometers) in the magnetron spraying device. Then, the metal gold is applied in the magnetron spraying device in such a way that the passing through at the reading-radiation wavelength (650 nanometers) amounts approximately to 70%. Then, in the centrifuge used in production of CD-R discs, the solution of co-polymer consisting of polystyrene, polyvinyl chloride and polymethyl metacrylate (MV 8000) in the mixture of toluene with xylylol (10 % by weight approximately) is applied. The application speed is 2,000 revolutions per minute. Then the obtained sample goes through drying during 1 minute at 90 ^{0}C, afterward the sample undergoes plasma chemical etching in the plasma gun PKhT 006 (ПХТ 006) M of the condenser type during 1 minute. The etching conditions are as follows: pressure - 20 Pa, airflow rate – 1.5 liter per hour, capacity - 500 W. Then, the sample is placed for 30 seconds in the aqueous solution containing 10% KI and 2.5% I2, rinsed in distilled water and dried by compressed air. After that, on the centrifuge, the adhesion layer consisting of 15% (by weight) of the solution of polyvinyl pirrolydone in the mixture of isopropanole and water taken in the ratio 1:2 is applied. The adhesion layer goes through drying during 3 minutes at 90 ^{0}C. By such method, the single-layer sample is produced.

Example 5.

An information pattern is moved from a nickel stumper onto a flat polycarbonate substrate in the process carried out on the standard DVD-discs production line by the method of photopolymerizing from the Epoxy Novolac Acrylate CN112B70 (Sartomer). Then the obtained replica is rinsed in the mixture of isopropylene and isobutyl alcohol (1:1) on the centrifuge used in the CD-R disks production. After that, to add the reflective coating, the replica is coated by a film of titanium dioxide (50 nanometers) in the magnetron spraying device. Then, on the centrifuge used in production of CD-R discs, the solution of co-polymer consisting of polystyrene and polymethyl metacrylate (MV 8000) in the mixture of butyl acetate with xylylol (10 % by weight approximately) is applied. The application speed is

2,000 revolutions per minute. Then the obtained sample goes through drying during 1 minute at 90 ^{0}C, afterward the sample undergoes plasma chemical etching in the plasma gun PKhT 006 (ПХТ 006) M of the condenser type during 1 minute. The etching conditions are as follows: pressure - 20 Pa, airflow rate – 1.5 liter per hour, capacity - 500 W. Then, the sample is placed for 50 seconds in the aqueous solution containing 10% HF and 2.5% NH_4F, rinsed in distilled water and dried by compressed air. After that, on the centrifuge, the adhesion layer consisting of 15% (by weight) of the solution of polyvinyl acetate in the mixture of ethyl cellosolve and isobutanol taken in the ratio 2:1 is applied. The adhesion layer goes through drying during 3 minutes at 90 ^{0}C. c, the single-layer sample is produced.

Example 6.

An information pattern is moved from a nickel stumper onto a flat polycarbonate substrate in the process carried out on the standard DVD-discs production line by the method of photopolymerizing from the Epoxy Novolac Acrylate CN112B70 (Sartomer). Then the obtained replica is rinsed in the mixture of isopropylene and ethyl alcohol (1:1) on the centrifuge used in the CD-R disks production. After that, to add the reflective coating, a diamond-like coating through spraying coats the replica. Then, on the centrifuge used in production of CD-R discs, the solution of co-polymer consisting of polystyrene, polyvinyl acetate and polymethyl metacrylate (MV 7000) in the mixture of toluene with xylylol (10 % by weight approximately) is applied. The application speed is 2,000 revolutions per minute. Then the obtained sample goes through drying during 1 minute at 90 ^{0}C, afterward the sample undergoes plasma chemical etching in the plasma gun PKhT 006 (ПХТ 006) M of the condenser type during 1 minute. The etching conditions are as follows: pressure - 20 Pa, airflow rate – 1.5 liter per hour, capacity - 500 W. After that, on the centrifuge, the adhesion layer consisting of 15% (by weight) of the solution of polyvinyl pirrolydone in the mixture of isopropanole and water taken in the ratio 1:2 is applied. The adhesion layer goes through drying during 3 minutes at 90 ^{0}C. By such method, the single-layer sample is produced.

Example 7.

An information pattern is moved from a nickel stumper onto a flat polymethyl metacrylate substrate in the process carried out on the standard DVD-discs production line by the method of photopolymerizing from the Ebecryl 809. Then the obtained replica is rinsed in the mixture of isopropylene and ethyl alcohol (1:1) in the centrifuge used in the CD-R disks production. After that, to improve diffusibility, the replica is coated by a film of silicon dioxide (50 nanometers) in the magnetron spraying device. Then, the metal gold is applied in the magnetron spraying device in such a way that the passing through on the reading-radiation

wavelength (650 nanometers) amounts approximately to 70%. Then, on the centrifuge used in production of CD-R discs, the solution of co-polymer consisting of polystyrene, polyvinyl chloride and polymethyl metacrylate (MV 8000) in the mixture of toluene with xylylol (10 % by weight approximately) is applied. The application speed is 2,000 revolutions per minute. Then the obtained sample goes through drying during 1 minute at 90 ^{0}C, afterward the sample undergoes plasma chemical etching in the plasma gun PKhT 006 (ПХТ 006) M of the condenser type during 1 minute. The etching conditions are as follows: pressure - 20 Pa, airflow rate – 1.5 liter per hour, capacity - 500 W. Then, the sample is placed for 30 seconds in the aqueous solution containing 10% KI and 2.5% I2, rinsed in distilled water and dried by compressed air. After that, on the centrifuge, the adhesion layer consisting of 15% (by weight) of the solution of polyvinyl pirrolydone in the mixture of isopropanole and water taken in the ratio 1:2 is applied. The adhesion layer goes through drying during 3 minutes at 90 ^{0}C. By such method, the single-layer sample is produced.

Example 8.

The single-layer sample obtained as described in Example 3 is used as a substrate according to the methodology disclosed in Example 3. Operation is repeated till 10-layer sample is obtained.

The spirit of the present invention can be disclosed briefly as follows:

The Multilayer Optical Information Carrier (MOIC) is a read-only information carrier (read-only-memory - ROM), in which the information stored by each layer is formed as a sequence of pits having different length values in compliance with CD-DVD standards. Information pits are formed as partially reflective metal "islands" or "islands" formed from some other material; all the rest area is transparent (this is similar to "flats" used in the reflective CD- or DVD- carriers of ROM- type).

Intermediate layers separate the MOIC information layers. The MOIC sandwich-like multi layer structure is located on a substrate made of a material having optical properties; at the same time, this material must ensure proper mechanical properties of the carrier. The information layers are aligned as concentric circles (for optical disks) or along two coordinates (for optical cards) and placed on the surfaces parallel to each other.

It is suggested to produce MOIC by the method of subsequent gluing of information layers with their simultaneous alignment. The MOIC information layers are formed by the method of injection molding or photopolymeric replication through applying the plasma chemical etching technology along with the liquid etching.

It is obvious to those skilled in the art that various changes and modifications are possible, without departing from the spirit and scope of the invention, and that what is briefly claimed is just an example that in any way may limit the inventor rights.

Those skilled in the art will readily appreciate that various modifications and changes may be applied to the embodiment of the invention as hereinbefore exemplified without departing from its scope defined in and by the appended claims.

WHAT IS CLAIMED IS:

1. A method for manufacturing of a multi-layer optical carrier, the method comprising:
- forming a plurality of optically transparent layers having a surface relief in a form of information pits and spaces therebetween;
- coating said surface of each of said optically transparent layers with at least partially reflective layer;
- coating said at least partially reflective layer with a planarizing layer;
- removing said planarizing layer from said spaces and partly from the pits; and
- removing said reflective layer from said spaces and from top portions of the pits.

2. The method of Claim 1, wherein said plurality of layers having is formed layer-by-layer on a substrate.

3. The method of Claim 1, wherein said at least partially reflective layer including a metal.

4. The method of Claim 1, wherein said at least partially reflective layer including a dielectric material.

5. The method of Claim 1, wherein said coating with at least partially reflective layer including a thermal spraying in vacuum.

6. The method of Claim 3, wherein said metal is selected from the group consisting of aluminum, chromium, vanadium, silver, gold.

7. The method of Claim 4, wherein said dielectric material having the refractive index different from the refractive index of said optically transparent layers having surface relief.

8. The method of Claim 4 wherein said dielectric material is selected from the group consisting of titanium dioxide, diamond-like film.

9. The method of Claim 1, wherein said planarizing layer including a polymeric base resistant to removing process of the reflective layer.

10. The method of Claim 2, wherein said planarizing layer including a polymeric base resistant to removing process of the reflective layer.

11. The method of Claim 9, wherein said planarizing layer including a polymeric base selected from the group consisting of polyalkyl methatrylate, polyaryl methakrylate, polyalkyl akrylate, polyaryl akrylate, polyakryl nitrile, polybutadien, polyisoprene, polyethylene terephthalate, polychloroprene, polyethylene adipate, polyamide, polyvinyl chloride, polyvinyl fluoride, polyvinyl alcohol, polyvinyl chloride, polyvinyl butirale, polystyrene, polyalkyl styrene, polyhalogene styrene, polyoxymethylene, polyethylene oxide, polypropylene oxide, polytetramethylene oxide, olytetra methylene adipate, polyvinyl naphthalane, polyarylate, polytetra fluorine ethylene, polycarbonate, polyurethane, polymethyl siloxen, polyvinylalkyl ester, polyvinyl acetate, polyisobutylene, polyvinyl cinnamite, polyvinylphenole, and their alkyl- and aryl ether, polyether, polyvinyl pirrolidone and (or) their co-polymers.

12. The method of Claim 1 wherein removing of said planarizing layer from the spaces and partly from the pits includes a plasma chemical etching.

13. The method of Claim 2 wherein removing of said planarizing layer from the spaces and partly from the pits includes a plasma chemical etching.

14. The method of Claim 1 wherein removing of said reflective layer from the spaces and from the top portions of the pits includes a liquid etching.

15. The method of Claim 2 wherein removing of said reflective layer from the spaces and from the top portions of the pits includes a liquid etching.

16. The method of Claim 13 wherein removing of said reflective layer from the spaces and from the top portions of the pits includes a liquid etching.

17. The method of Claim 14 wherein removing of said reflective layer from the spaces and from the top portions of the pits includes a liquid etching.

18. The method of claim 1 wherein forming said plurality of optically transparent layers having surface relief including an injection molding.

19. The method of claim 2 wherein forming said plurality of optically transparent layers having surface relief including an injection molding.

20. The method of claim 13 wherein forming said plurality of optically transparent layers having surface relief including an injection molding.

21. The method of claim 14 wherein forming said plurality of optically transparent layers having surface relief including an injection molding.

22. The method of claim 16 wherein forming said plurality of optically transparent layers having surface relief including an injection molding.

23. The method of claim 17 wherein forming said plurality of optically transparent layers having surface relief including an injection molding.

24. The method of claim 1 wherein forming said plurality of optically transparent layers having surface relief including a photo polymeric replication.

25. The method of claim 2 wherein forming said plurality of optically transparent layers having surface relief including a photo polymeric replication.

26. The method of claim 13 wherein forming said plurality of optically transparent layers having surface relief including a photo polymeric replication.

27. The method of claim 14 wherein forming said plurality of optically transparent layers having surface including a photo polymeric replication.

28. The method of claim 15 wherein forming said plurality of optically transparent layers having surface relief including a photo polymeric replication.

29. The method of claim 16 wherein forming said plurality of optically transparent layers having a surface relief in a form of information pits and spaces therebetween including a photo polymeric replication.

30. The method of claim 1 wherein coating with said planarizing layer including a dipping.

31. The method of claim 2 wherein coating with said planarizing layer including a dipping.

32. The method of claim 9 wherein coating with said planarizing layer including a dipping.

33. The method of claim 10 wherein coating with said planarizing layer including a dipping.

34. The method of claim 11 wherein coating with said planarizing layer including a dipping.

35. The method of claim 12 wherein coating with said planarizing layer including a dipping.

36. The method of claim 1 wherein coating with said planarizing layer including a centrifuging with a subsequent drying.

37. The method of claim 2 wherein coating with said planarizing layer including a centrifuging with a subsequent drying.

38. The method of claim 9 wherein coating with said planarizing layer including a centrifuging with a subsequent drying.

39. The method of claim 10 wherein coating with said planarizing layer including a centrifuging with a subsequent drying.

40. The method of claim 11 wherein coating with said planarizing layer including a centrifuging with a subsequent drying.

41. The method of claim 12 wherein coating with said planarizing layer including a centrifuging with a subsequent drying.

Fig. 1

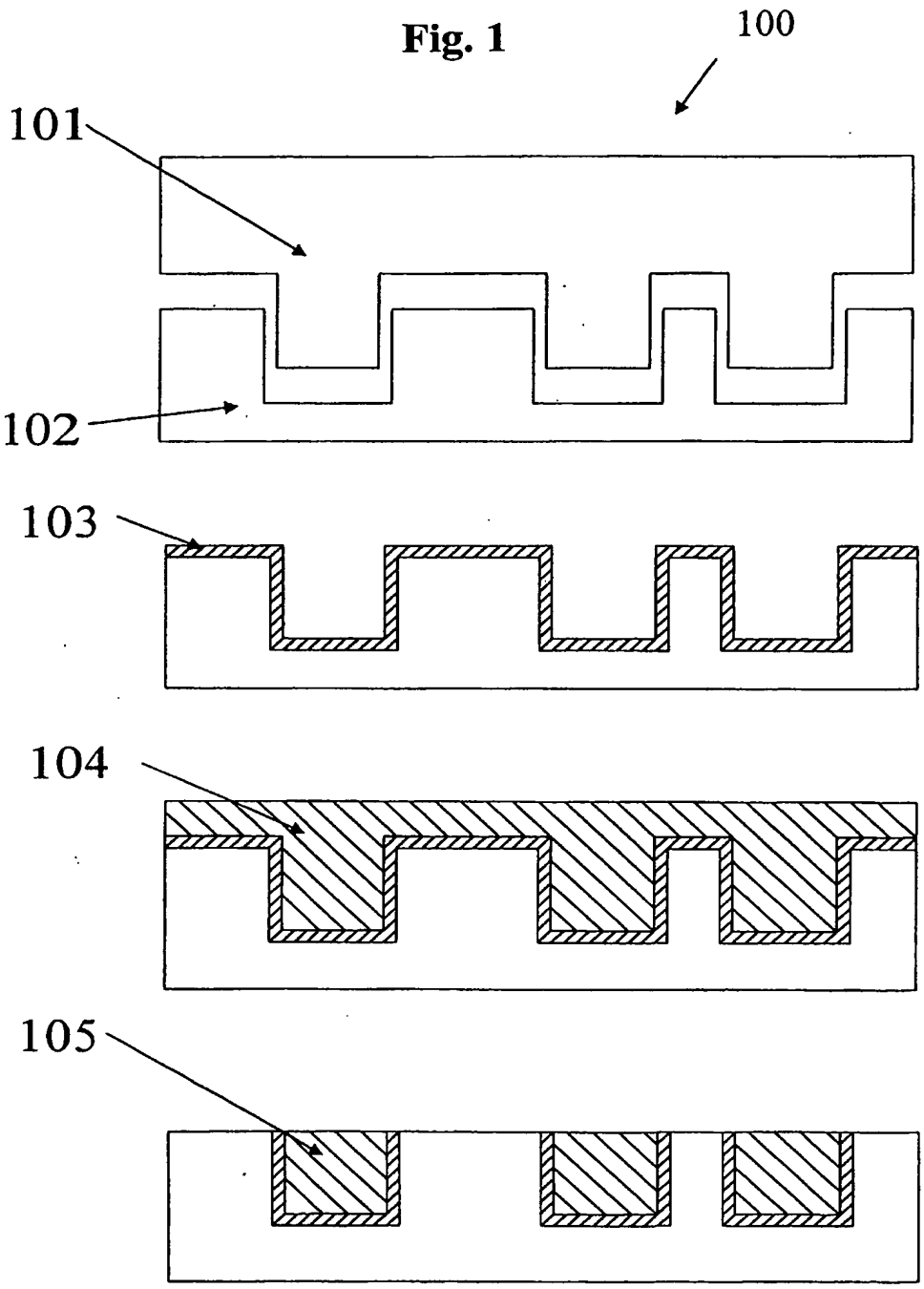


Fig. 2

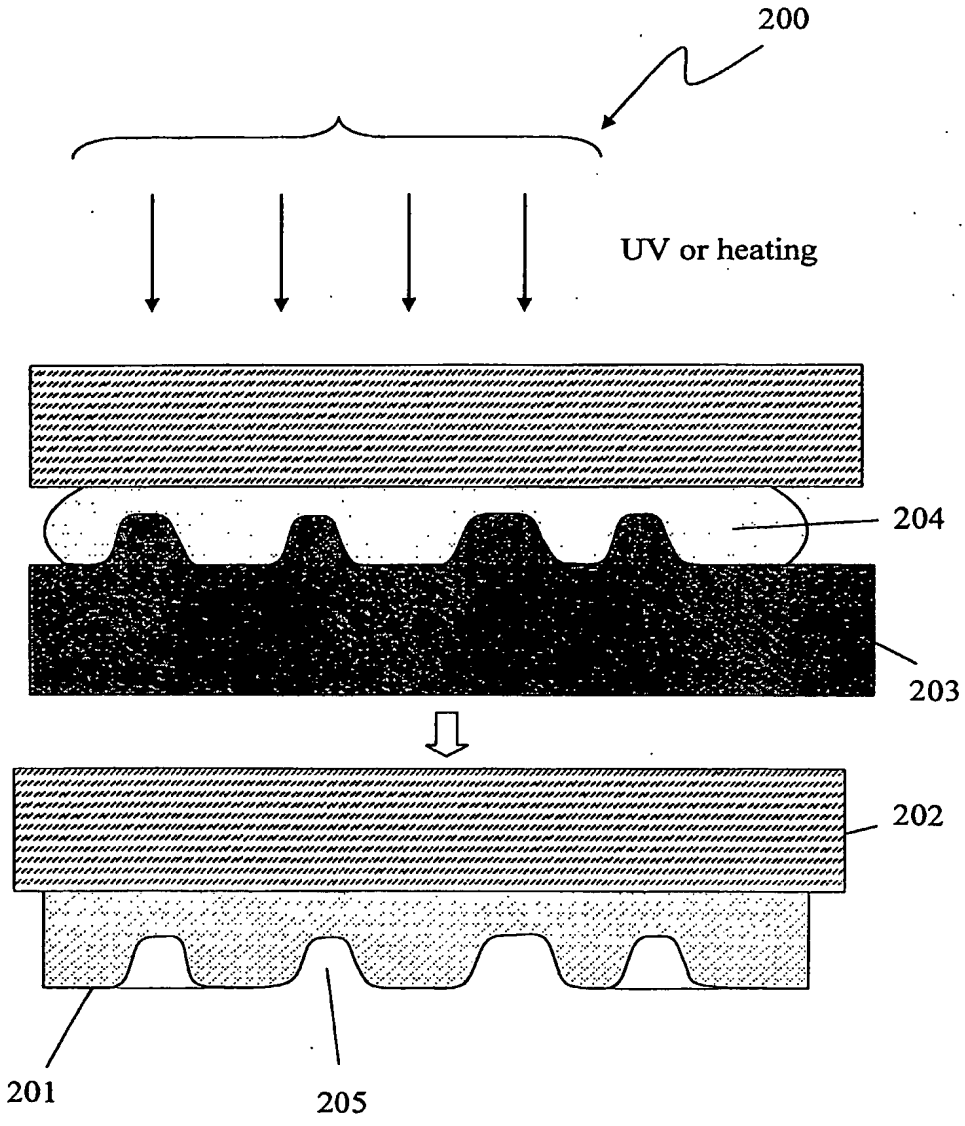


Fig. 3

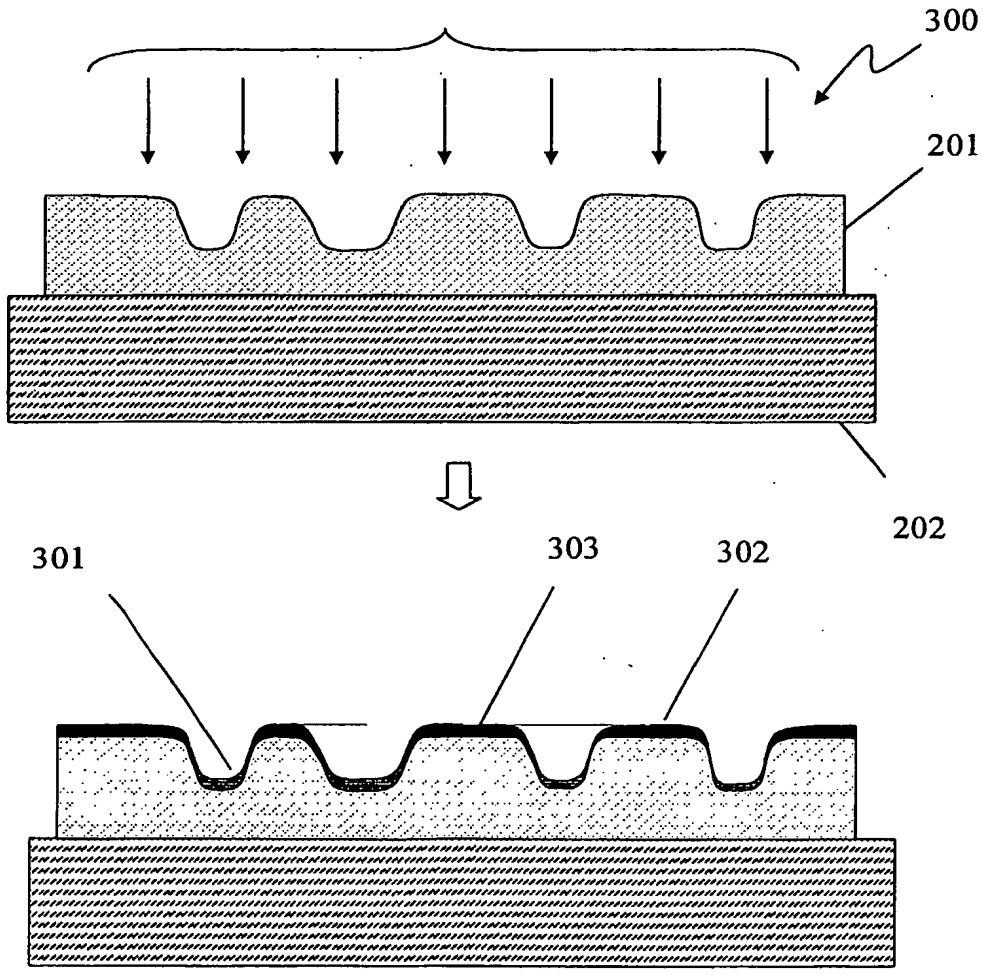


Fig. 4

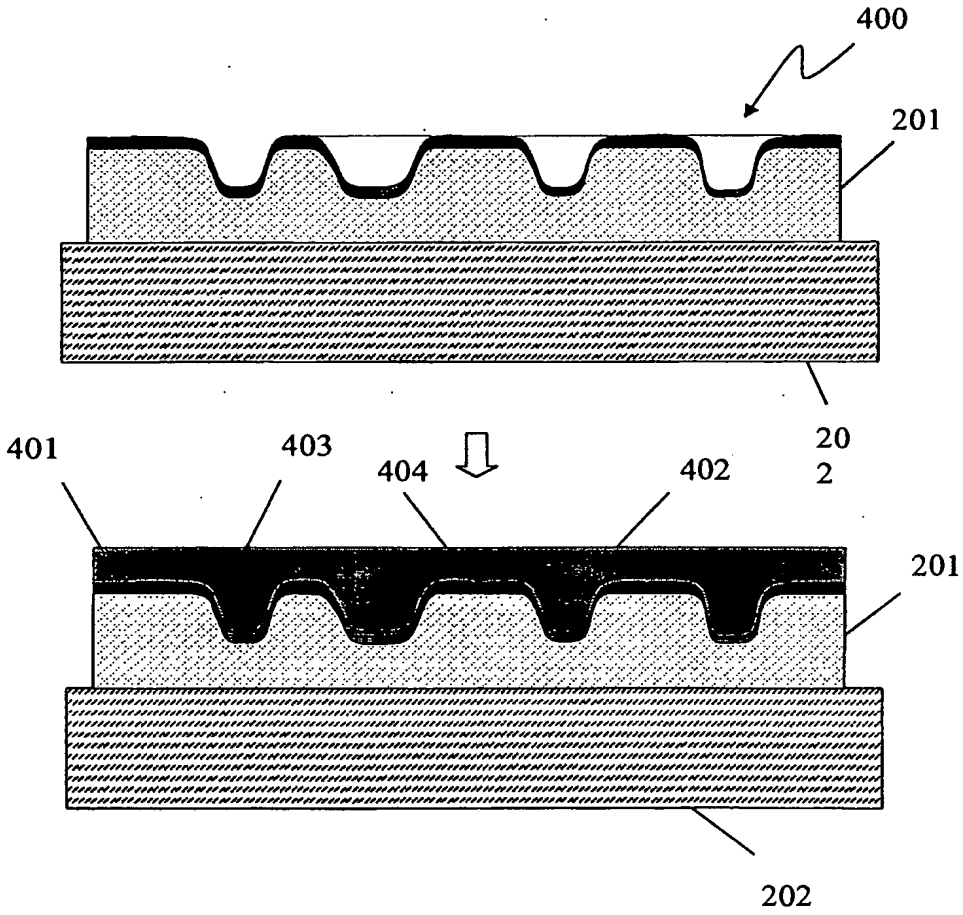


Fig. 5

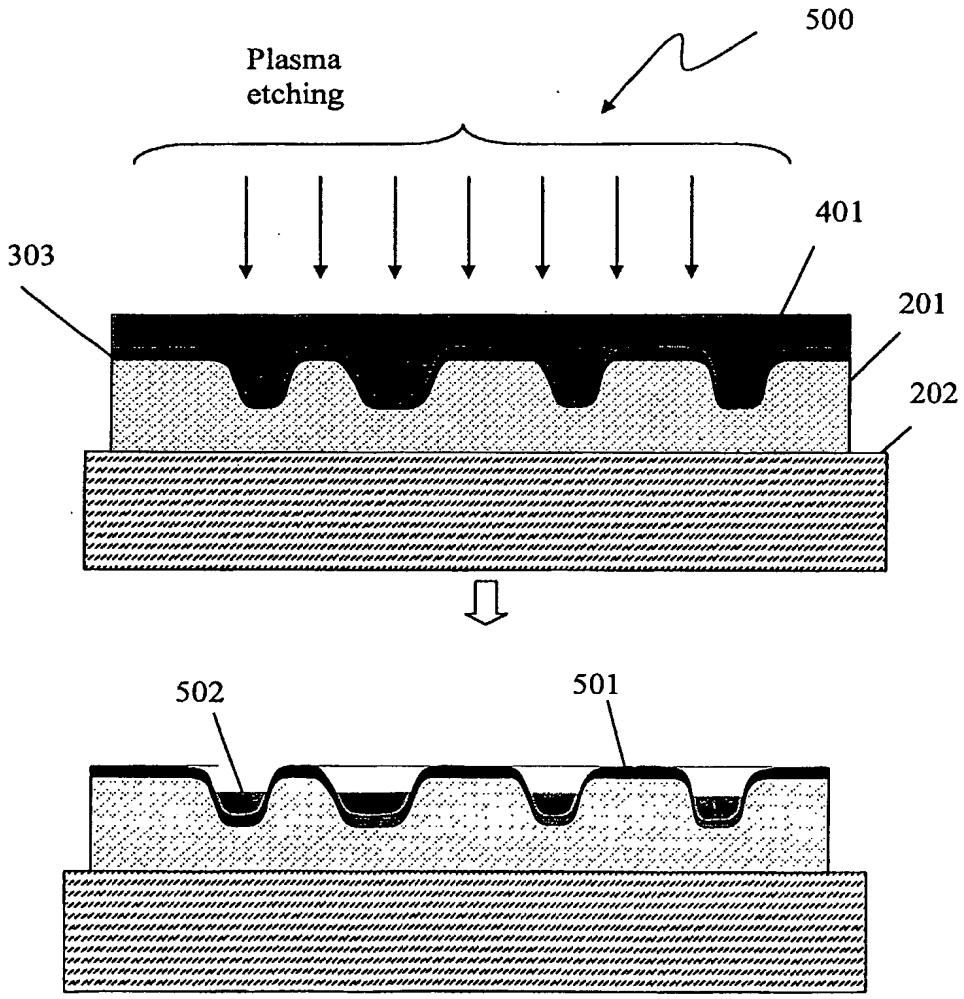


Fig. 6

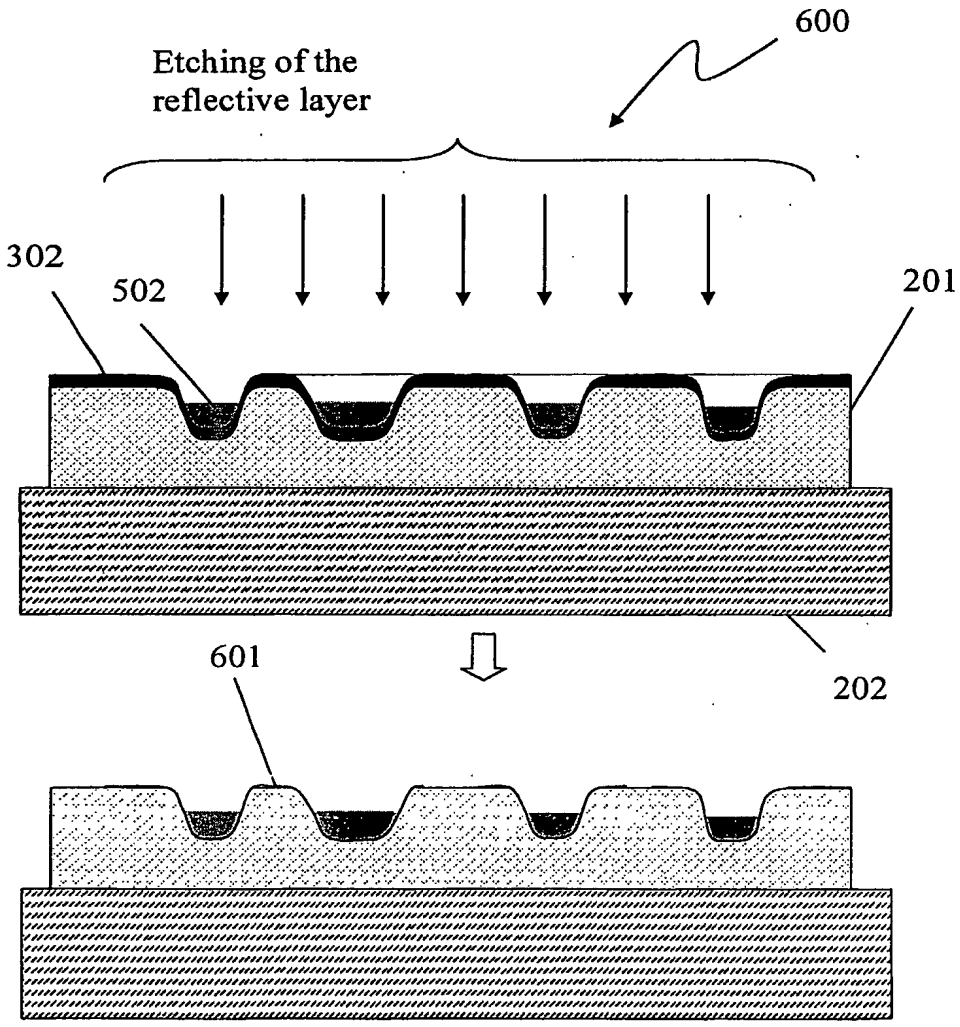


Fig. 7

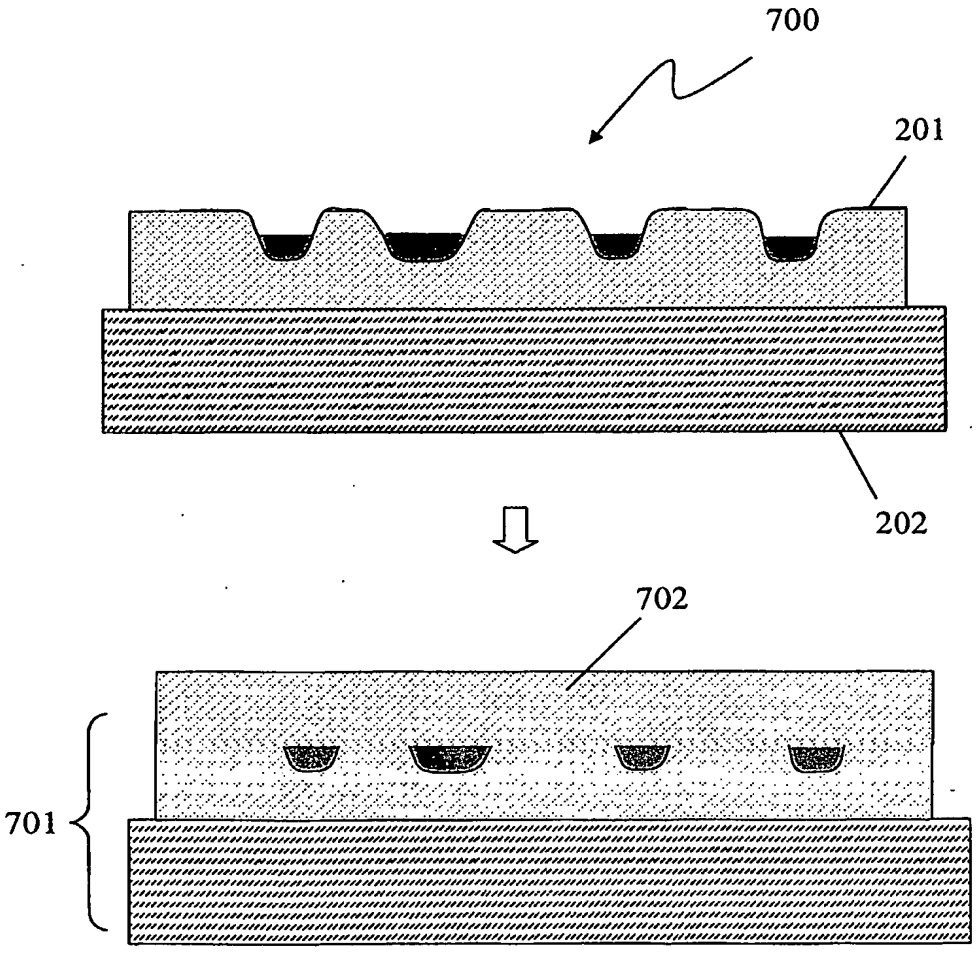
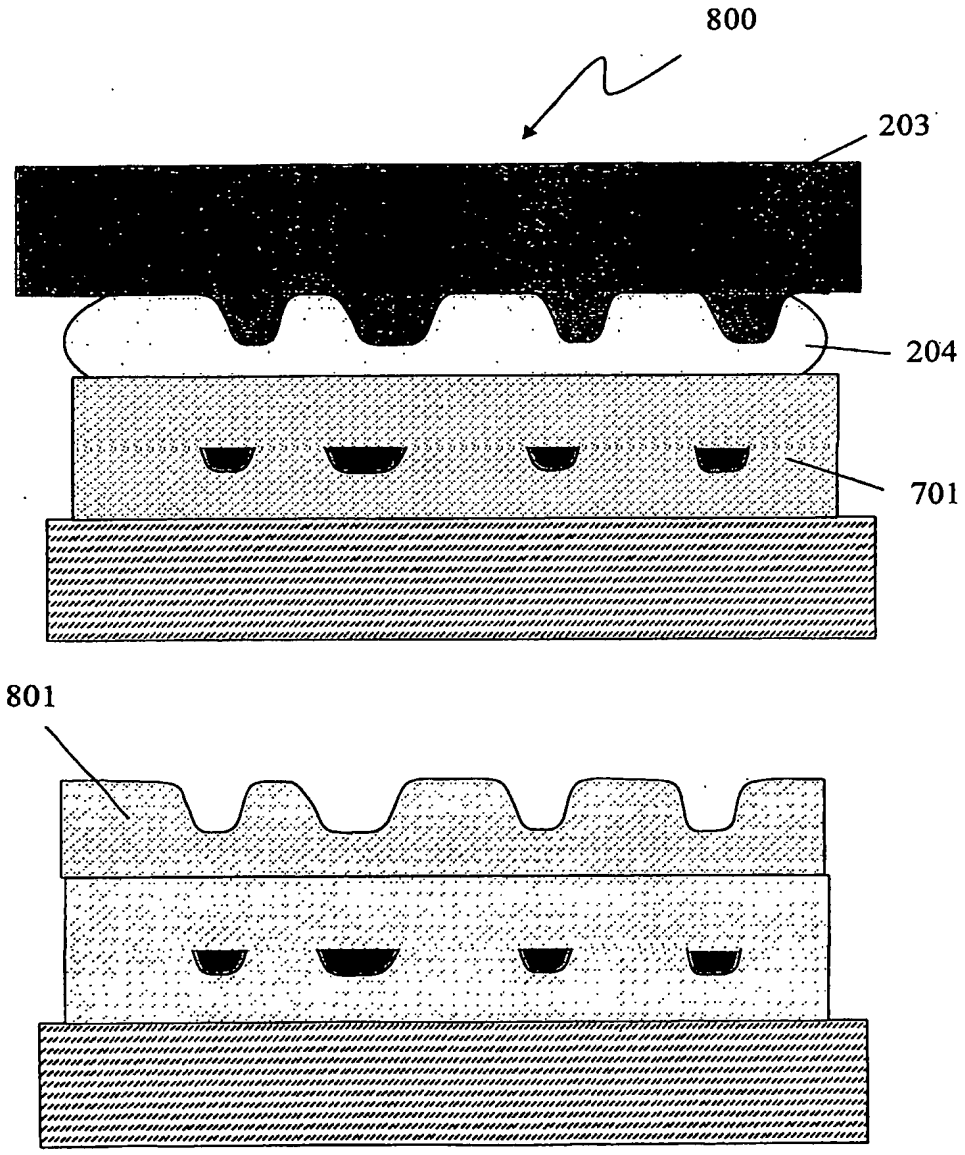


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/41715

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : B29D 11/00; G11B 7/24, 7/26, 3/70, 5/84
US CL : 216/24; 369/275.1, 283
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 216/24; 369/275.1, 283; 428/64.1; 430/321

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,309,729 B1 (GLUSHKO et al) 30 October 2001 (30.10.2001), see entire document, especially column 7, lines 1-50.	1-40

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 August 2004 (13.08.2004)	25 AUG 2004
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230	Authorized officer Gregory Mills Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

PCT/US03/41715

Continuation of B. FIELDS SEARCHED Item 3:
EAST (keywords: etch, remove, layer, multilayer, pits, reflective, metal, metallic, optical, disk, media, medium, information carrier, MOIC, CD, DVD, recording, retrieval, storage)